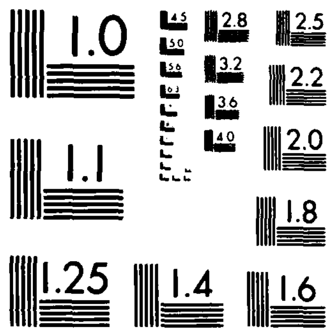
AD-A171 593 CONVENTIONAL WIRE FENCES: SECTION 521 US ARMY CORPS OF ENGINEERS WILDLIFE..(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS ENVIR.. 1/1

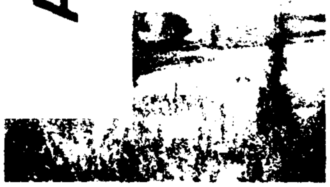
UNCLASSIFIED L E MARCY ET AL. JUL 86 WES/TR/EL-86-19 F/G 13/2 NL


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

(12)

US Army Corps of Engineers

AD-A171 593



ENVIRONMENTAL IMPACT RESEARCH PROGRAM

TECHNICAL REPORT EL-86-19

CONVENTIONAL WIRE FENCES

Section 5.2.1, US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL

by

Larry E. Marcy, Chester O. Martin

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631

July 1986

Final Report

Approved For Public Release; Distribution Unlimited

Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Under EIRP Work Unit 31631

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

ADA 171 593

REPORT DOCUMENTATION PAGE

Form Approved OMB No 0704 0188 Exp Date Jun 30, 1986

1a REPORT SECURITY CLASSIFICATION: Unclassified	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S): Technical Report EL-86-19	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION: USAEWES Environmental Laboratory; 6b OFFICE SYMBOL (If applicable)	7a NAME OF MONITORING ORGANIZATION
6c ADDRESS (City, State, and ZIP Code): PO Box 631 Vicksburg, MS 39180-0631	7b ADDRESS (City, State, and ZIP Code)
8a NAME OF FUNDING/SPONSORING ORGANIZATION: US Army Corps of Engineers; 8b OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c ADDRESS (City, State, and ZIP Code): Washington, DC 20314-1000	10 SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO; PROJECT NO; TASK NO; WORK UNIT ACCESSION NO: EIRP 31631

11 TITLE (Include Security Classification)
Conventional Wire Fences: Section 5.2.1,
US Army Corps of Engineers Wildlife Resources Management Manual

12 PERSONAL AUTHOR(S)
Marcy, Larry E., and Martin, Chester O.

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final report	FROM ____ TO ____	July 1986	38

16 SUPPLEMENTARY NOTATION
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Fences; Wire fences; Conventional wire fences; (Continued)

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

A management techniques report on conventional wire fences is provided as Section 5.2.1 of the US Army Corps of Engineers Wildlife Resources Management Manual. The report was prepared as a guide to assist Corps biologists and resource managers in the selection and implementation of conventional wire fence techniques where fencing is required or desirable for wildlife and habitat management programs. Topics covered for fences include description, materials, design, construction, installation, placement, maintenance, personnel and costs, and cautions and limitations.

A variety of fence designs are often required for multipurpose management on Government lands. When improperly constructed, fences can impede wildlife movements and often result in death or injury. Techniques presented in this report for conventional wire fences

(Continued)

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION: Unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL	22b TELEPHONE (Include Area Code); 22c OFFICE SYMBOL

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

18. SUBJECT TERMS (Continued).

Fences and crossings
Wildlife management
Management practices and techniques
Wildlife fence designs
Habitat management

19. ABSTRACT (Continued).

emphasize designs that will restrict livestock yet allow wildlife passage. Basic fence designs are described, and details are presented on the design, construction, and installation of wire fences in a variety of settings. Specification drawings and lists of materials required are included. Guidelines are provided for developing a complete fencing plan, and appropriate cautions and limitations are discussed for planning, constructing, and maintaining fences on Federal lands.

PREFACE

This work was sponsored by the Office, Chief of Engineers (OCE), US Army, as part of the Environmental Impact Research Program (EIRP), Work Unit 31631, entitled Management of Corps Lands for Wildlife Resource Improvement. The Technical Monitors for the study were Dr. John Bushman and Mr. Earl Eiker, OCE, and Mr. Dave Mathis, Water Resources Support Center.

This report was prepared by Mr. Larry E. Marcy, Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, Tex., and Mr. Chester O. Martin, Wetlands and Terrestrial Habitat Group (WTHG), Environmental Laboratory (EL), US Army Engineer Waterways Experiment Station (WES). Mr. Marcy was employed by WES under an Intergovernmental Personnel Act contract with Texas A&M University during the period this report was prepared. Mr. Martin, Team Leader, Wildlife Resources Team, WTHG, was principal investigator for the work unit. Mr. Jerry W. Davis, Wildlife Biologist, USDA Forest Service, Tonto National Forest, Ariz., and Mr. Michael L. Hanson and Ms. Hope Hanson, Agri-Fence Co., Rough and Ready Calif., are acknowledged for contributing information used in this report. Precautionary information on the use of wood preservatives was provided by Mr. Robert S. Wardwell, Armed Forces Pest Management Board, Forest Glen Section, WRAMC, Washington, D.C., and Mr. Michael Stroukoff, US Army Armaments Research, Development, and Engineering Center, Dover, N. J. Manuscript review was provided by Dr. Wilma A. Mitchell, WTHG; Mr. Ted B. Doerr, Colorado State University, Fort Collins, Colo.; and Mr. E. Paul Peloquin, US Army Engineer Division, North Pacific, Portland, Oreg.

The report was prepared under the general supervision of Dr. Hanley K. Smith, Chief, WTHG, EL; Dr. Conrad J. Kirby, Chief, Environmental Resources Division, EL; and Dr. John Harrison, Chief, EL. Dr. Roger T. Saucier, WES, was Program Manager, EIRP. The report was edited by Ms. Jessica S. Ruff of the WES Publications and Graphic Arts Division (PGAD). Drawings were prepared by Mr. John R. Harris, Scientific Illustrations Section, PGAD, under the supervision of Mr. Aubrey W. Stephens, Jr.

At the time of publication, COL Allen F. Grum, USA, was Director of WES, and Dr. Robert W. Whalin was Technical Director.

This report should be cited as follows:

Marcy, Larry E., and Martin, Chester O. 1986. "Conventional Wire Fences: Section 5.2.1, US Army Corps of Engineers Wildlife Resources Management Manual," Technical Report EL-86-19, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

NOTE TO READER

This report is designated as Section 5.2.1 in Chapter 5 -- MANAGEMENT PRACTICES AND TECHNIQUES, Part 5.2 -- FENCES AND CROSSINGS, of the US ARMY CORPS OF ENGINEERS WILDLIFE RESOURCES MANAGEMENT MANUAL. Each section of the manual is published as a separate Technical Report but is designed for use as a unit of the manual. For best retrieval, this report should be filed according to section number within Chapter 5.

CONVENTIONAL WIRE FENCES

Section 5.2.1, US ARMY CORPS OF ENGINEERS
WILDLIFE RESOURCES MANAGEMENT MANUAL

A variety of fence designs are often required for multipurpose management on Government lands. Purposes of fence construction include: (1) delineation of project boundaries, (2) division of agricultural lease areas, (3) control of trespass in operation and maintenance areas, (4) protection from safety hazards, (5) exclusion of livestock in wildlife management areas, and (6) exclusion of livestock and wildlife at revegetation sites. Fence design and installation can be an important part of a multipurpose management program, but fences are often constructed with disregard for wildlife populations. When improperly constructed, fences can impede wildlife movements and often result in injury or death. Techniques presented below for conventional wire fences emphasize designs that will restrict livestock yet allow wildlife passage. Modified designs for critical or special-use areas are described in chapter sections 5.2.2 - 5.2.4.

DESCRIPTION

Fences constructed where they might impede movement of wildlife should incorporate features to ensure the least possible hindrance. Passable fences are constructed so wildlife can jump over the fence, crawl under the bottom strand or through middle strands, or pass through special openings in the

fence (U.S. Fish and Wildlife Service 1978). Fences designed to allow wildlife free movement have 3 or 4 strands of wire; the bottom strand is smooth wire 16 to 18 in. above the surface of the ground (Antelope States Workshop 1974), and the maximum height of the top strand is 40 in. (Interstate Antelope Conference 1962) (Fig. 1). The wire strands above the bottom strand can be 2-pronged barbed wire. To reduce the chance of injury to species that often jump fences, a smooth wire may be substituted for the top barbed wire. Where elk (*Cervus elaphus*) and moose (*Alces alces*) frequently cross fences, wooden poles should be substituted for the top wire strand to prevent injuries and reduce damage to the fence (Vallentine 1971). Elk and moose tend to drag their hind legs when jumping over a fence, and the pole is more readily seen and less easily damaged. Deer (*Odocoileus* spp.) are also less apt to get their legs caught in the wire.

Fences are basically categorized as either boundary fences or division fences. A boundary fence is usually a 4-strand fence built along ownership lines. Legal requirements for boundary fences are usually specified by State laws, and the required type and construction vary from state to state

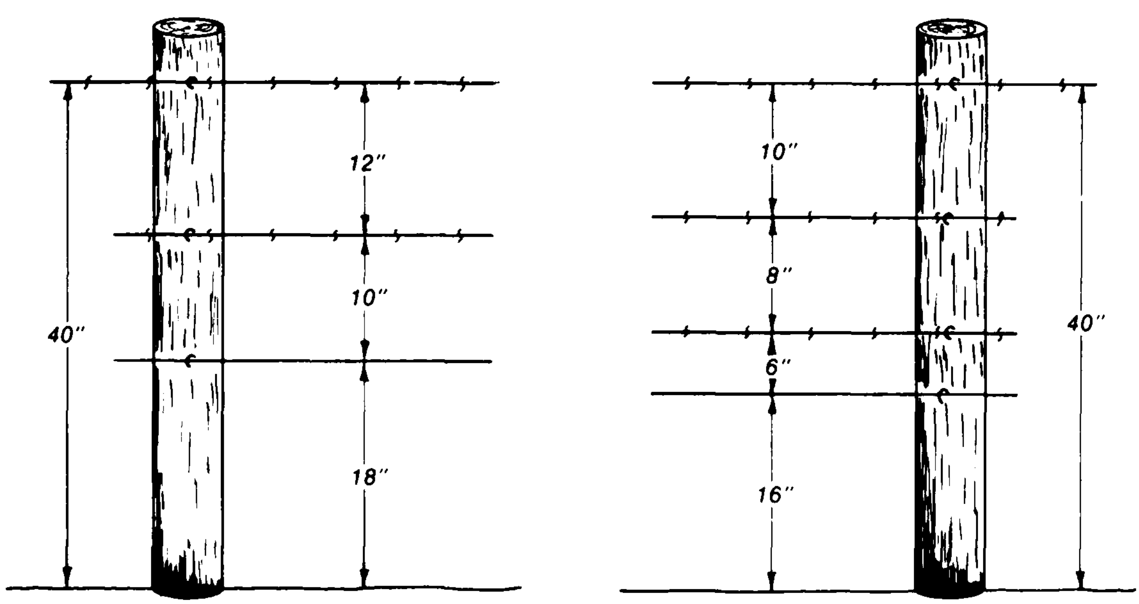


Figure 1. Wire spacing for a 3- and 4-strand boundary or division fence designed to allow wildlife free passage. Note the smooth bottom wire; a smooth wire may also be used for the top strand. A wooden pole should be substituted for the top strand along wildlife migration routes

(Vallentine 1971). Therefore, it is recommended that the manager consult the appropriate State statutes prior to building boundary fences. A division fence is usually a 3- or 4-strand fence that divides range areas into smaller units or, where necessary, serves as an impassable enclosure or exclosure for special uses. The components used in a typical wire fence are defined below and illustrated in Figure 2.

<u>Corner post</u> - A large-diameter wooden post (≥6-in. diam) that serves as an anchor point for tying off wire and is capable of withstanding high tension. For strength, a corner post must be set a minimum of 36 in. deep, and preferably 48 in. deep (Hanson 1982).

<u>Corner brace post</u> - A wooden support post (≥6-in. diam) that helps distribute high-tension forces applied to a corner post. All corner brace posts should be cross-braced.

<u>Brace bar</u> - A 4- to 6-in.-diam wooden post that rigidly connects corner posts and corner brace posts. Steel pipe (3-in. diam) may be substituted for wooden brace bars where more strength is needed.

<u>Line post</u> - Wood, metal, or fiberglass posts positioned equidistant along the fence lines to support the weight of the wire.

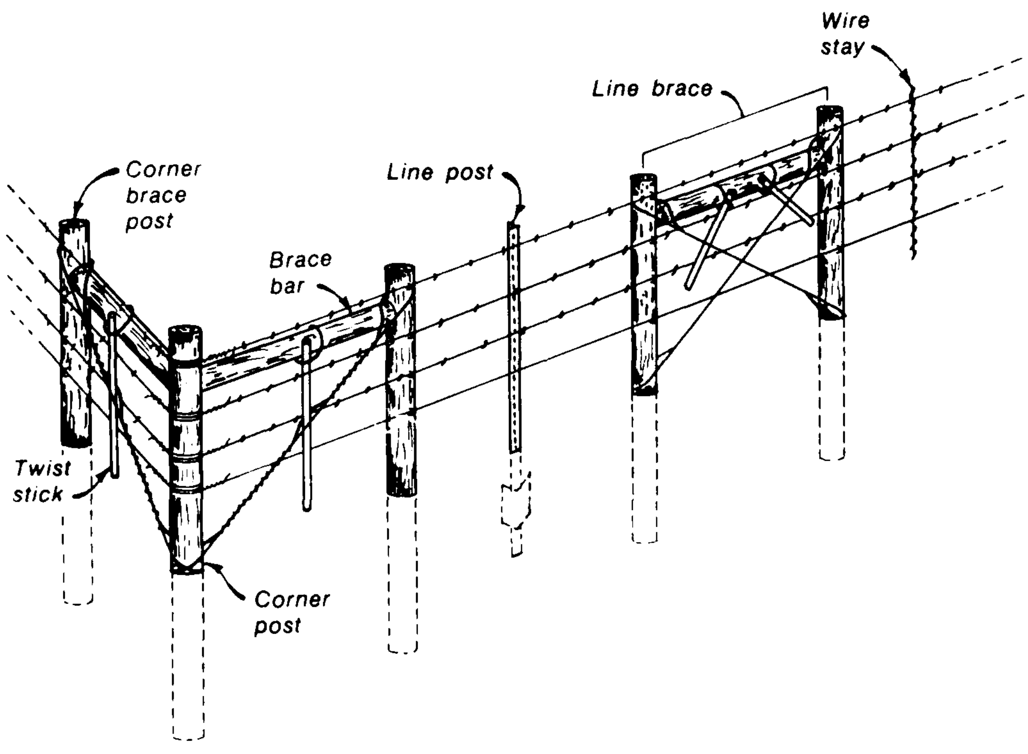


Figure 2. Components of a conventional 4-strand barbed-wire fence. Line posts may be either metal or wood

Line brace - A wooden brace consisting of at least 2 vertical posts (≥6-in. diam) and a brace bar. Line braces are spaced at intervals of no more than 1/4 mile along the fence line. They serve as solid attachment points that will not give as wire is being strung. Line braces prevent wires from becoming slack over the entire length of the fence following breakage or accidents.

Stay - A wire strand separator made of wood (1-1/2- to 2-in. diam) or 9-1/2-ga wire that maintains wire spacing between line posts. All stays should be at least 48 in. long and must rest solidly on the ground when attached. Stays are necessary to make the fence more rigid, allowing the animals crawling through wires a better chance to escape the fence. Fence wires without stays may twist together and entrap animals.

MATERIALS

Materials required for a conventional fence include posts, braces, wire, stays, staples, and nails. Details are provided below and under the topic heading Design, Construction, and Installation. Table 1 lists materials needed to construct 1 mile of conventional wire fence with 1 wire gate and 1 line brace every 1/4 mile.

Posts and Braces

Supports for most conventional fences include corner posts, corner brace posts, brace bars, line posts, and line braces (see Fig. 2). Posts used for fence construction on range sites are usually wooden, but steel and fiberglass posts are also common; steel-reinforced concrete posts are occasionally used in special situations.

Post strength is a function of material and diameter (Jepson et al., undated). A comparison of post strength showed that pine posts 4-1/2 in. in diameter required approximately a 2000-lb force applied at the top of a post before breaking, whereas a concrete post of the same diameter was only 80% as strong (Leighton 1978). Henderson (1966) found that steel T-posts were only 7.8% as strong as wood posts. Jepson et al. (undated) report that fiberglass posts are 70% lighter than steel posts and can withstand greater side stress than steel T-posts. The methods and depth of setting wood posts have a tremendous effect on post stability. Driven posts have been found to be 1-1/2 times more rigid than posts set in dug holes; they also have greater lifting force resistance (Jepson et al., undated). Hanson (1982) reported that post strength was doubled when the depth of post holes was increased 6 in. over the minimum 36 in. Recommended size requirements for various types of posts are given in Table 2.

Table 1. Materials needed to build 1 mile of conventional wire fence using wood posts only or both wood and steel posts (after USDA Forest Service 1972)*

Item	Use	Quantity
FENCE WITH WOOD POSTS ONLY		
Posts		
4-in. diam × 6 ft long	Line posts	255
6-in. diam × 7-1/2 ft long	Corner and brace posts	21
5-in. diam × 8 ft long	Horizontal brace	6
5-in. diam × 10 ft long	Diagonal brace	9
Wire (galvanized)		
Barbed, 12-1/2-ga, 80-rod roll	Top 3 fence strands	16
Smooth, 12-1/2-ga, 80-rod roll	Bottom fence strand	4
Smooth, 9-1/2-ga	Guy and attachment wire	300 ft
Stays (twisted)**		
9-1/2-ga, 42 in. long	Separate wire strands	525
Staples		
1-1/2 in. long	Secure wire to posts	45 lb
Nails		
40d	Secure braces to posts	4 lb
FENCE WITH WOOD AND STEEL POSTS		
Posts (wood)		
4-in. diam × 6 ft long	Line posts	49
6-in. diam × 7-1/2 ft long	Corner and brace posts	21
5-in. diam × 8 ft long	Horizontal braces	6
5-in. diam × 10 ft long	Diagonal braces	9
Post (steel)		
6-ft-long T-post	Line posts	206
Wire (galvanized)		
Barbed, 12-1/2-ga, 80-rod roll	Top 3 fence strands	16
Smooth, 12-1/2-ga, 80-rod roll	Bottom fence strands	4
Smooth, 9-1/2-ga	Guy and attachment wire	300 ft
Stays (twisted)**		
9-1/2-ga, 42 in. long	Separate wire strands	525
Staples		
1-1/2 in. long	Secure wire to posts	10 lb
Nails		
40d	Secure braces to posts	4 lb
Wire clips		
9-ga, twist-on	Clip wire to T-posts	620

* The fence design includes materials for 1 wire gate and 1 brace every 1/4 mile.

** If wood stays are used, add 6 in. to the above lengths.

Table 2. Minimum size requirements for fence posts (from USDA Forest Service 1972)

Type of post	Length (ft)	Diameter (in.)
Wooden		
Line post	6	4*
Corner, angle, brace	7-1/2	6
Gate	7-1/2	6
Corral	9-1/2	6
Steel T-shaped		
Line post only	5-1/2	1-3/8 × 1-3/8 × 1/8
Fiberglass		
T-shaped	6	1-1/4 across
Round line	6	2-3/8

* Pressure-treated posts of split material should have an average top width 1 in. larger than those indicated.

The life expectancy of wooden posts is determined by the (1) species, (2) natural rot-resistance of the wood, (3) ability to absorb and retain preservative, and (4) climate (Vallentine 1971; Jepson et al., undated). Black locust (*Robinia pseudoacacia*) and osage orange (*Maclura pomifera*) posts are highly resistant to decay; they should last 15 to 25 years without treatment in humid areas and up to 30 or 40 years in arid regions (Vallentine 1971). Other acceptable species for fence posts are cedar and juniper (*Juniperus* spp.), mulberry (*Morus* spp.), catalpa (*Catalpa* spp.), baldcypress (*Taxodium distichum*), white oak (*Quercus alba*), redwood (*Sequoia* spp.), sassafras (*Sassafras albidum*), and Gambel oak (*Quercus gambelii*); posts made from these woods will normally last up to 15 years without treatment or 20 to 25 years when treated. All pine posts (*Pinus* spp.) should be treated with preservative.

Posts with large amounts of sapwood should be treated with a wood preservative. A variety of compounds are commercially available, but some of the commonly used wood preservatives have recently been designated as restricted use pesticides by the Environmental Protection Agency (EPA). These are pentachlorophenol (penta), creosote, and the following inorganic arsenicals: copper-chromated arsenate (CCA), ammonia-chromated arsenate (ACA), and ammonia-chromated zinc arsenate (ACZA). Thus, extreme care should be employed when handling pressure-treated lumber, and EPA labels and consumer information

sheets must be strictly followed when applying the compounds (Robert S. Wardwell, Armed Forces Pest Management Board, Washington, D.C., pers. commun., May 1986). For additional information on precautions for the use of wood preservatives, the reader should contact Mr. Wardwell or Mr. Michael Stroukoff, US Army Armaments Research, Development, and Engineering Center (ARDEC), Dover, New Jersey.

Wire

Barbed wire. The USDA Forest Service (1972) recommended the use of "American Glidden" 2-strand, 12-1/2-ga galvanized barbed wire or "Sheffield 100" 2-strand, 13-1/2-ga high-tensile-strength galvanized wire. Barbs should be 2-pointed and placed at 4-in. intervals. Barbed wire procured by the General Services Administration (GSA) is described as barbed wire (galvanized) of ASTM standard A121, zinc-coated steel (Jepson et al., undated).

Gaucho wire is 15-1/2 ga, yet it has the same breaking strength as standard 12-1/2-ga barbed wire and has a class III zinc coating, which gives it 25% longer life (Jepson et al., undated). Gaucho wire is currently selling for 20% to 25% less than conventional barbed wire. However, it is less flexible than conventional wire, which may make fence construction more difficult. The wire manufacturer should certify the quality of the materials used in the wire. Fence wire manufactured by foreign companies may not meet the rigid standards established by U.S. manufacturers.

High-tensile wire. High-tensile barbless wire has a breaking strength in excess of 100,000 psi, whereas conventional wire never reaches this strength (Jepson et al., undated). Most high-tensile wire used is 12-1/2 ga and has a class III zinc coating for extended life span. New Zealand high-tensile wire (Hi-Ten) is 12-1/2 ga and has a breaking strength of more than 190,000 psi (Hanson 1982). Its class III zinc coating increases the life span of the wire from 35 to 50 years. Advantages of high-tensile wire are (1) smoothness (no barbs), which reduces or prevents injury to animals; (2) resiliency and high strength, which allow further stretching and springback than conventional wire; and (3) a total cost that compares favorably with conventional wire even though more linear feet are required. Disadvantages are that: (1) it is hard to work with due to its stiffness; (2) it requires a special figure-8 in-line splicing knot (or a special press tool and sleeves can be used); and (3) special equipment is needed to string the wire efficiently. A comparison of selected characteristics of various types of wire is given in Table 3.

Table 3. Comparison of selected characteristics of various wire types (from Jepson et al., undated)

Type of Wire	Gauge	Diameter (in.)	Breaking Strength (lb)	Breaking Strength (psi)	Yield Strength (lb)	Yield Strength (psi)	ASTM Coating (class)	Years Until Wire Reaches Half-Strength*	Recommended Wire Tension (lb)
USS MAX-TEX 200	12-1/2	0.099	1,815	235,788	1,620	209,955	III	18	250
New Zealand high-tensile	12-1/2	0.097	1,420	191,200	1,070	144,800	III	18	340
Standard high-tensile	12-1/2	0.099	918	119,000	755	98,100	III	18	**
2-strand barbed wire	12-1/2	0.10	95	70,000	879	57,000	I	12	100 to 400+
Gaucho	15-1/2	0.067	950	135,000	712	102,000	III	15	300

* For coastal or industrial climates; dry climates will increase life 3-fold.

** Not found in literature.

\+ For 1 wire of 2 strands (consult manufacturer's recommendations).

Stays and Staples

Stays. The purposes of stays are to maintain wire spacing, act as visual barriers to livestock and wildlife, and distribute pressure evenly to all wires in the span (Jepson et al., undated). Stays are used in lieu of additional posts because they are less expensive and easier to install. They are usually constructed of wire, wood, or fiberglass. Wire stays (9-1/2-ga) are most commonly used and are less expensive than wood and fiberglass; however, they are not as effective as a visual deterrent to livestock or wildlife, and they bend easily. In contrast, wood stays 1-1/2 to 2 in. thick and 48 in. long provide a strong, rigid wire support and a good visual barrier. Wood stays are attached by presawed angle cuts, clips, or staples. Fiberglass stays have the advantage of being light, long-lasting, and strong; however, they are more expensive than other types of stays. Fiberglass stays attach with special light-duty clips.

Staples. Hammer-driven staples are used to attach fence wire to wood posts and stays. The USDA Forest Service (1972) recommended using No. 9 Washburn and Moen gauge (W&M), standard polished or galvanized staples 1-1/2 to 1-3/4 in. long with slash-cut points. Fence wire is attached to slotted steel posts by No. 10 W&M 1-1/2-in. polished or galvanized staples with 3/16-in. spread, or it may be tied to the fence post with 14-ga wire.

Equipment

Fence construction requires a minimum number of tools, including: (1) power posthole auger or manual posthole digger, (2) chain saw, (3) hammer, (4) level, (5) tape measure, (6) 1/2-in. wood chisel, (7) pliers, (8) wire cutters, (9) fencing tool, (10) crescent wrench, (11) wood plane, (12) line post driver, (13) prize bar, (14) rammer or tamping tool, (15) wire strainer, (16) shovel and spade, and (17) spinning jenny (a device that aids in dispensing wire). Techniques for using special tools, such as the spinning jenny, are discussed in the following section.

DESIGN, CONSTRUCTION, AND INSTALLATION

There is no uniform standard of wire fence construction since the methods used are based on many factors. These include (1) topography, (2) water distribution, (3) vegetation, (4) range condition, and (5) resources,

manpower, and financial considerations. Basic guidelines for all types of wire fences are provided below.

The usual order of construction for any wire fence is to: (1) survey and mark all boundary and division fence locations; (2) clear the fence line of all brush; (3) set corner, corner brace, line brace, and rise and dip posts in post holes at least 36 in. deep; (4) set line posts on an accurate line between installed corner and line brace posts at least 24 in. deep; (5) string wire on the side of the post that will receive the greatest pressure from livestock, drifted snow, tumbleweeds, or other factors; and (6) stretch and staple one wire at a time (beginning with the top wire). Wires should be stretched tightly and uniformly by section between brace installations (USDA Forest Service 1972).

Construction Methods

Fence lines should be precisely located, marked with metal or wooden stakes, and flagged before construction is started, particularly if construction is to be contracted (USDA Forest Service 1972). The fence line should be cleared of any brush or obstructions. Hanson (1982) suggests blading the line to cut down rises and to fill in gaps; blading also facilitates construction and maintenance. However, extreme care must be taken when clearing erosive sites (Vallentine 1971). A maximum of a 1/4 mile should be fenced at a time.

Corner posts. Posts and braces should first be placed along the designated fence line. Minimum dimensions for corner and line brace installations are given in Figure 3. Soil conditions dictate the type of corner and line braces used. In heavy soils, all corner braces should consist of 3 posts and 2 brace bars, whereas sandy soils require corner braces of 5 posts and 4 brace bars. In sandy soils, the addition of log or rock anchors (deadmen) attached to the corner post may prevent the post from shifting as tension is applied.

One set of corner posts and braces should be installed at a time. Post holes are dug at least 36 in. deep and 42 in. (center-to-center) apart. Post holes should be dug so that the corner and corner brace posts have a 2-in. outward lean at the top of the post; the lean should be away from the direction of pull. Corner and corner brace posts are then placed in their respective holes, and are measured and marked 40 in. from the surface of the ground up one side of each post. This gives the correct height for placement of the brace bars and the top wire. The ends of each brace bar are trimmed to a

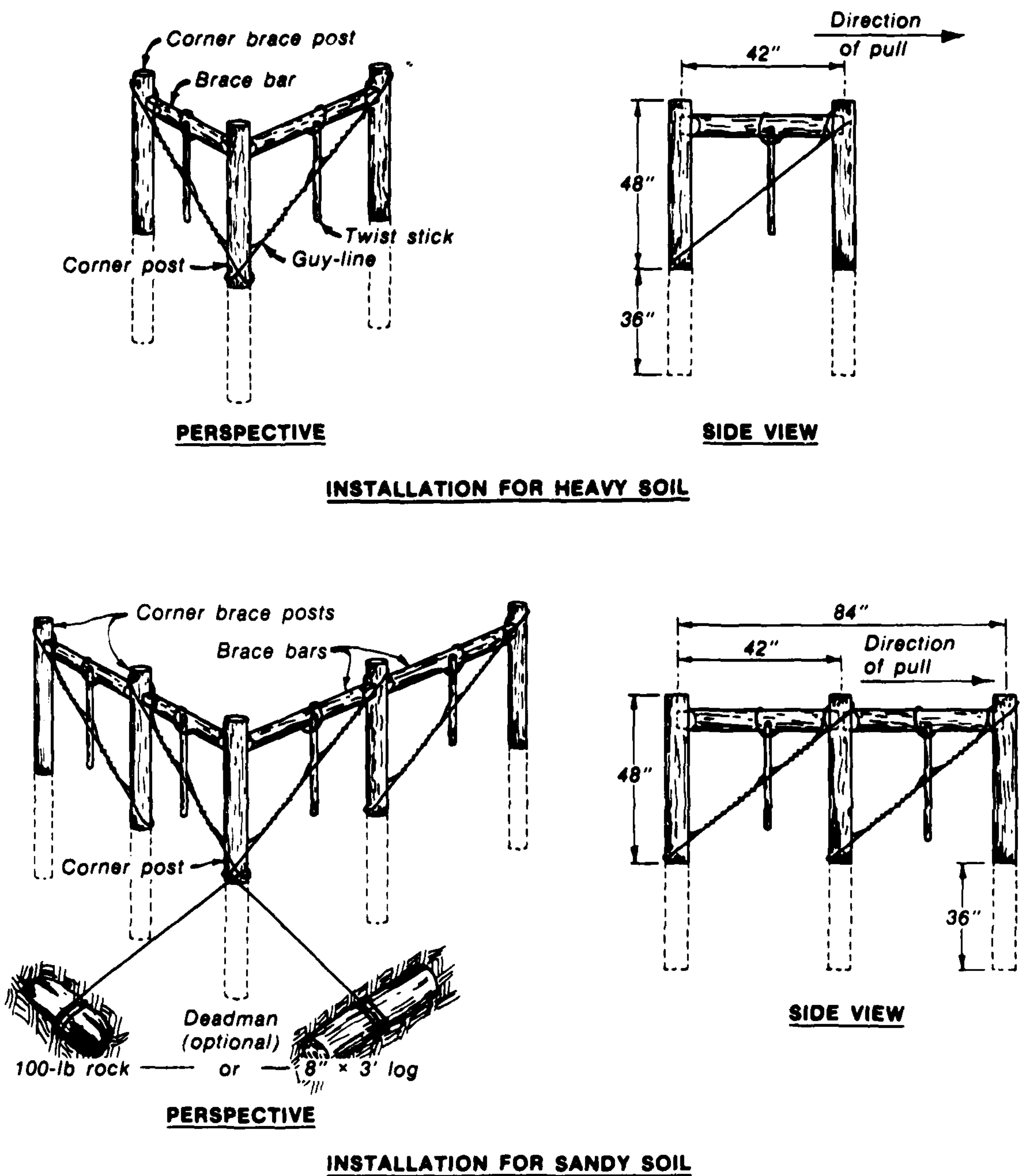


Figure 3. Corner and brace installation for heavy soils (top) and sandy soils (bottom), showing optional anchor points (deadmen) that can be used in sandy soils (adapted from USDA Forest Service 1972)

3-in. square, as shown in Figure 4. A 1-1/2-in. chisel is then used to notch each brace and corner post at the previously measured 40-in. mark, the mark being the top of the notch. Each notch should be cut approximately 1 to 2 in. deep; each corner post will have 2 notches 90 deg apart. Brace bars should fit snuggly in the notches. In areas where livestock concentrate, corner brace strength can be increased by using a 3-in.-diam steel pipe instead of a wooden brace bar (USDA Forest Service 1972). Brace and corner posts should be drilled with 3-1/2-in.-diam holes, 3 in. deep to secure the pipe brace bars in the posts.

Corner and corner brace posts are then set in their respective holes, and brace bars are positioned in the notches. A piece of rope tied across the top of each corner and brace post helps keep brace bars from falling out while post holes are being filled. Each vertical post should be placed against the side of the hole from which tension will be applied when fence wires are tied off (Fig. 5). Fill dirt should then be shoveled into the holes and tamped firmly with a rammer in at least 4 layers to provide a firm setting. Posts should not be set in concrete, as water traps easily between the post and concrete, resulting in more rapid decay than would otherwise occur.

After posts have been firmly set, guy-lines should be used to secure the corner, corner brace posts, and brace bars together. Doubled guy-lines (9-1/2- or 12-1/2-ga smooth wire) are attached to the top of each brace post and to the bottom of the corner post. Attachment is made by wrapping one end of the guy-lines around the top of the brace post and over the top of the brace bar; the short end is then twisted at least 6 times around the remaining portion of the wire. The guy-lines should be secured in similar fashion to the bottom of the corner post at ground level. The bottom portion of the guy-lines should be double-stapled to keep the lines from riding up the post when the wires are tightened. Proper staple installation is illustrated in Figure 6.

An alternative method of securing guy-lines is to drill a 1/2-in.-diam hole horizontal through the post and 2 to 3 in. deep into the end of the brace bar. A 1/2-in.-diam steel rod (rebar) can be driven into the post and brace bar. Approximately 2 in. of rod should remain outside the post. The guy-line can then be wrapped around the rod and tied off as mentioned above. A twist stick (2 in. in diameter and 24 to 36 in. long) is inserted between the 2 wires of the guy-line, and the wires are tightened by twisting, using the

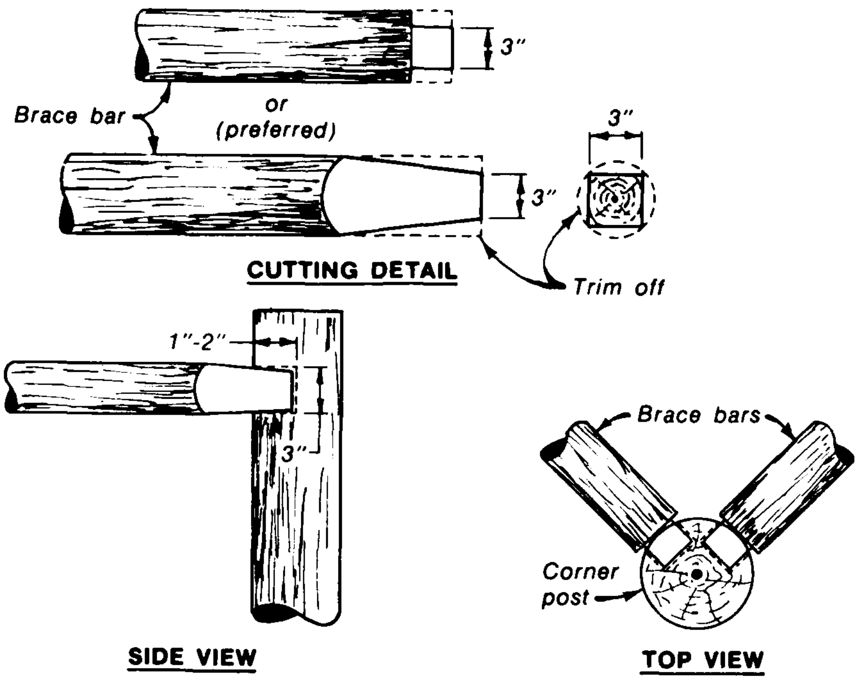


Figure 4. Cutting detail and installation of brace bar. Brace bars are connected to corner posts and corner brace posts

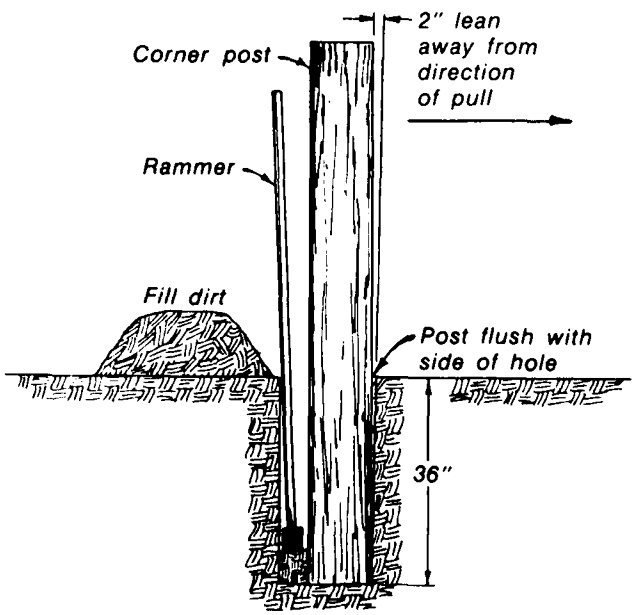


Figure 5. Proper placement of corner post against side of post hole

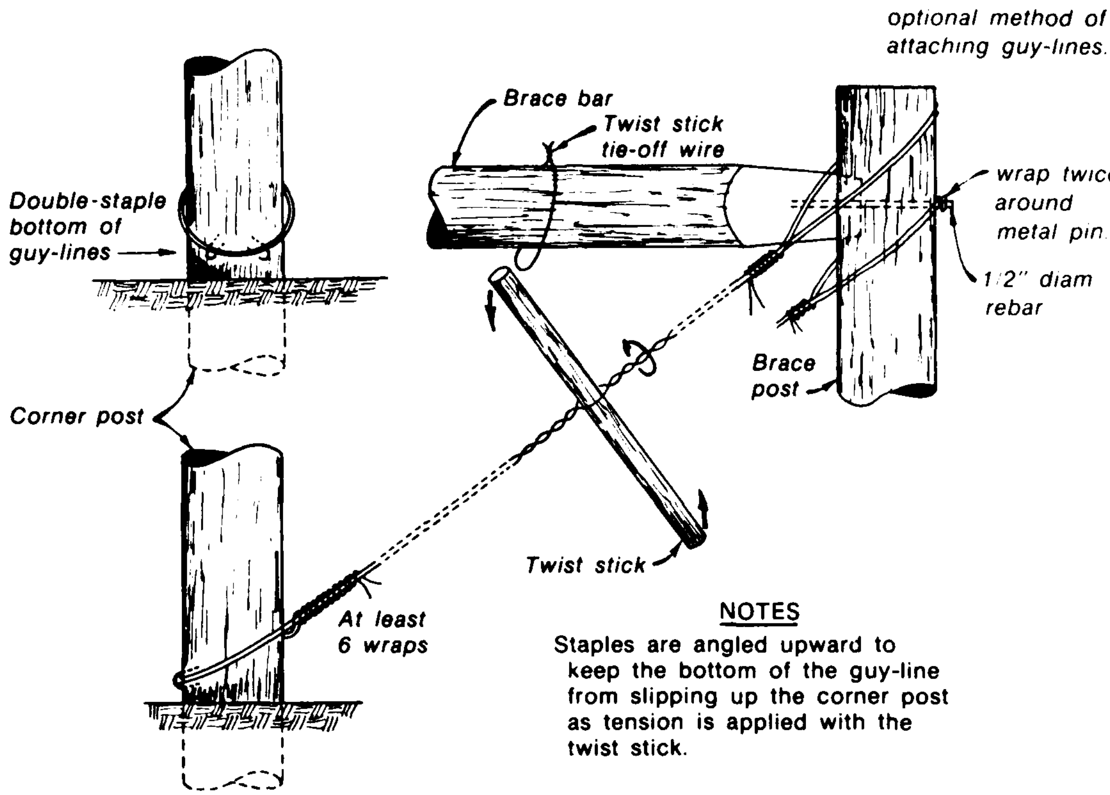
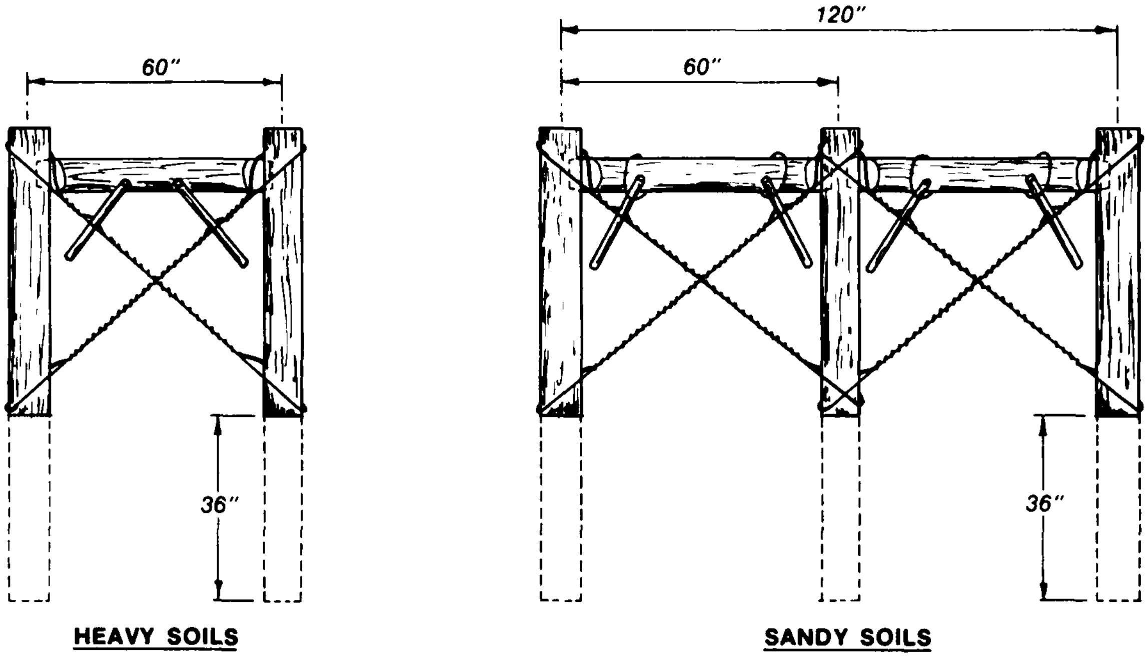


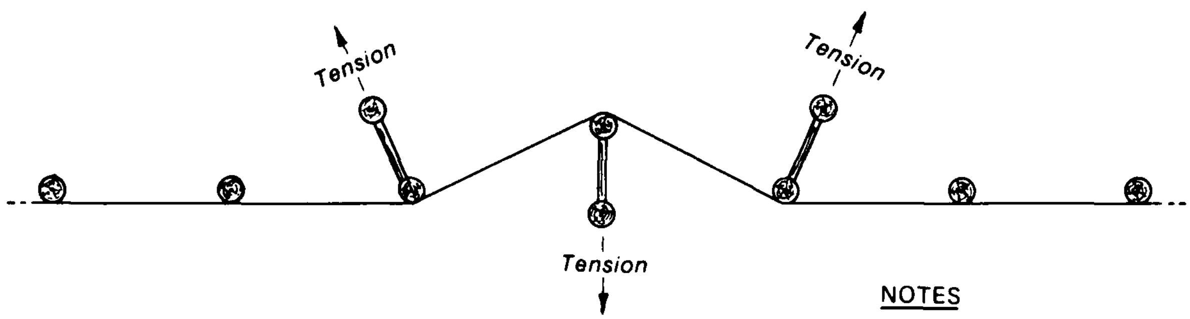
Figure 6. Application of double guy-lines, twist stick, and staples to secure corner post, brace post, and brace bar. Note placement of staples in the corner post

stick as a handle. The guy-lines should be tightened until the posts and brace bars are solid. A wire loop around the brace bar can be used to tie off the twist stick. (After all of the fence wires have been stretched and tied off, any slack in the corner and brace posts can be removed with the twist stick.)

Line braces and posts. The type of line brace installation is also dependent on soil type and follows the same guidelines as described for corner posts (Fig. 7a). Line braces are used on long fence sections every 1/4 mile and serve as stretching and tie-off stations. Any displacement in the fence line that creates an angle requires a line brace set where it will counteract the wire tension (Fig. 7b). Specifications for line posts and stays vary according to topography and weather regime. Table 4 shows the types of posts and stays required and the distance between line posts and stays for



a. LINE BRACE CONSTRUCTION



NOTES

Angles of 160 to 180 deg need only have the posts set with a 1" outward lean at the top.

Angles of 120 to 160 deg need a single brace assembly and a 2" outward lean.

Angles of less than 120 deg need a double-brace assembly and a 2" outward lean.

b. ANGLE BRACING — PLAN VIEW

Figure 7. Line brace construction for heavy soils and sandy soils (a), and plan view showing placement of angle bracing (b) (adapted from USDA Forest Service 1972)

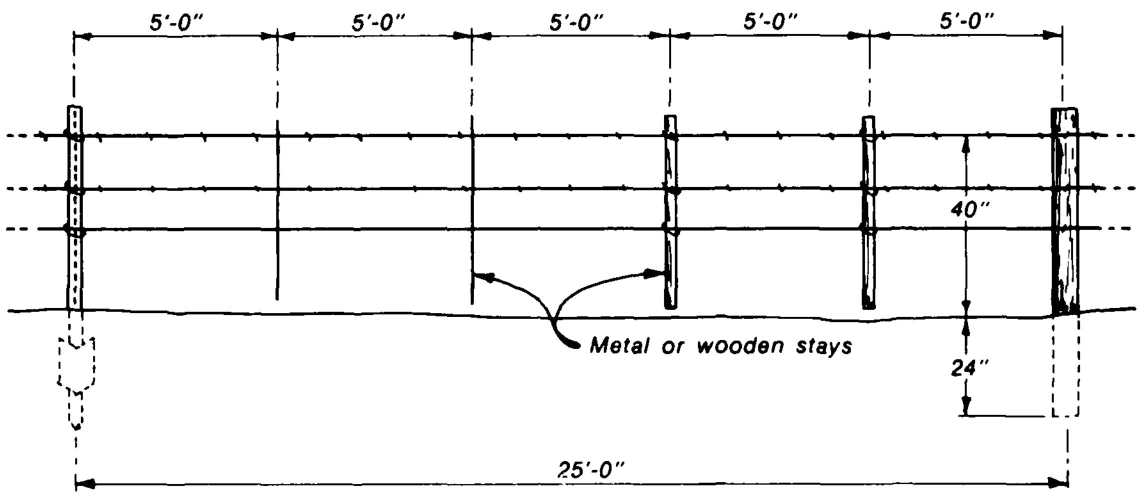
Table 4. Specifications for line posts and stays for 6 categories of division and boundary fences (after USDA Forest Service 1972)

Fence Type and Location	Type of Line Posts and Stays	Distance Between Line Posts	Distance Between Stays
3-strand division fence (level ground, light or no snow country)	Metal or wooden posts and stays	25'	5'0"
3-strand division fence (steep ground, moderate snow country)	Metal or wooden posts, wooden stays	20'	5'0"
4-strand division fence (level ground, light or no snow country)	Metal or wooden posts, wooden stays	20'	5'0"
4-strand division fence (level ground, moderate snow country)	Metal or wooden posts, wooden stays	16'	5'4"
4-strand boundary or right-of-way fence (level ground, light or no snow country, below 5000-ft elevation)	Metal or wooden posts, wooden stays	25'	8'4"
4-strand boundary or right-of-way fence (level ground, moderate snow country, 5000- to 9000-ft elevation)	Metal or wooden posts, wooden stays	20'	6'8"

6 categories of 3- and 4-strand wire boundary and division fences; examples are illustrated in Figure 8.

Line posts are set a minimum of 24 in. deep on as straight a line as possible between corner posts. Wooden posts are positioned against the side of the hole as described for corner and brace posts, and the holes are packed solidly with fill-dirt. Power post drivers can be used for setting metal line posts or wooden posts if the posts are relatively straight and pointed on one end (Vallentine 1971). Post driving is feasible in most soils where holes can be dug with a power auger, and it has the advantage of rapidly and firmly setting posts without additional tamping.

Wire strands. The final step in fence construction is wire attachment. The end of the top wire should first be connected to the corner post with a double wrap and at least 6 twists, and then be strung to the next corner post



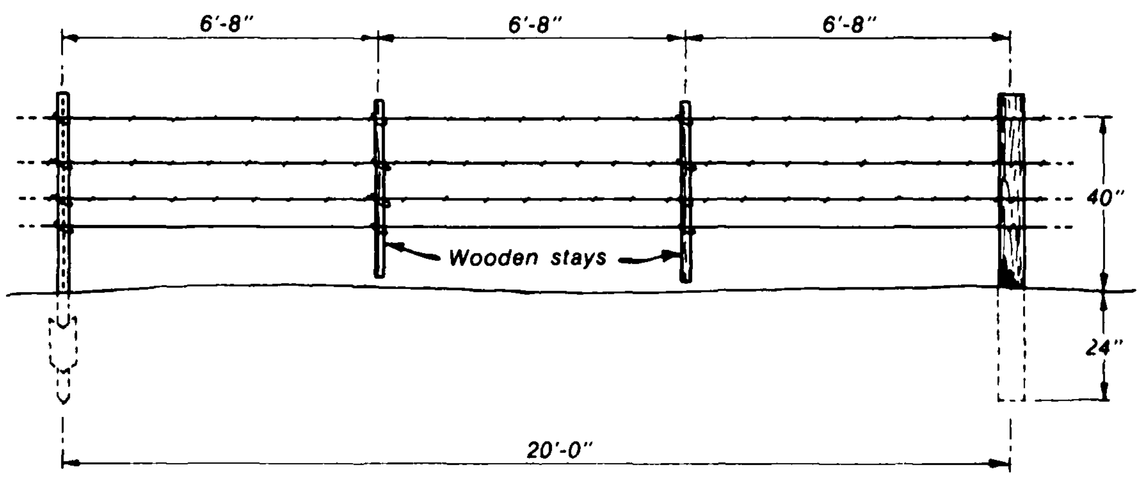


Figure 8. Three-strand level-ground division fence with metal or wooden line posts and stays for light snow country (top), and 4-strand level-ground right-of-way or roadside fence with wooden or metal line posts and wooden stays for moderate snow country at elevations from 5000 to 9000 ft (bottom) (adapted from USDA Forest Service 1972)

or line brace (Fig. 9). Barbed wire comes on a spool and can be strung easily by hand by placing a piece of 1/2-in.-diam pipe through the spool holes and allowing the wire to unwind or by using a "spinning jenny" attached to a vehicle. Smooth wire should be payed out only with a spinning jenny (Fig. 10).

After the top wire has been strung between corner posts or between corner and line braces, it should be pulled as tight as possible by hand. A chain-type wire stretcher should then be attached to the corner post and wire strand. For barbed wire, a tension of 100 to 200 lb should be applied, depending on the manufacturer's recommendations. Hanson (1982) reported a simple method of measuring wire tension by using an inexpensive meter made from a spring-type scale and a 1- × 2- × 44-in. board with 2 hooks screwed 40 in. apart (Fig. 11). The hooks are placed over a wire strand, and the scale is attached to the center of the wire strand between the hooks. Tension is determined by pulling up on the scale until the wire strand deflects 1/2 in. The reading on the scale is multiplied by 20 to give the tension (expressed in pounds) on the wire. When the proper tension has been applied, the wire should be cut from the spool; enough wire should be left to make 2 turns around the post and a 6-twist tie-off. The wire stretcher can be released after the wire has been secured. An alternative to using a chain-type wire stretcher is to use a permanent in-line wire stretcher and wire tension indicator spring attached at one end of each strand or in the middle of a strand (Fig. 11). Most tension springs are marked to indicate tension at 0, 100, 200, or 300 lb.

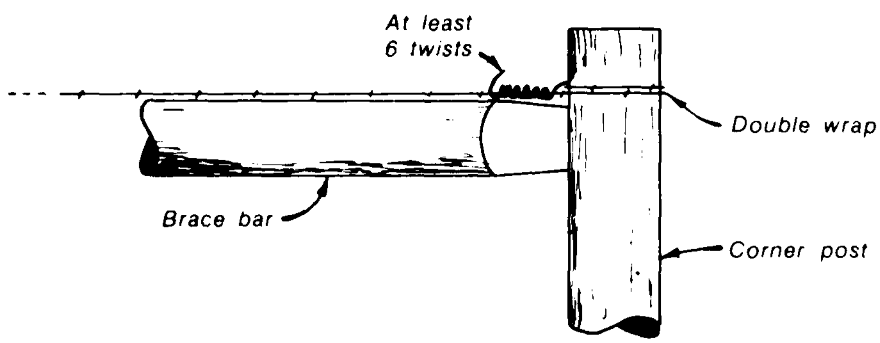


Figure 9. Proper attachment of top wire strand to the corner post. The wire is tied off to the post with 2 wraps and at least 6 twists. Note placement of wire along top of the bra^e bar

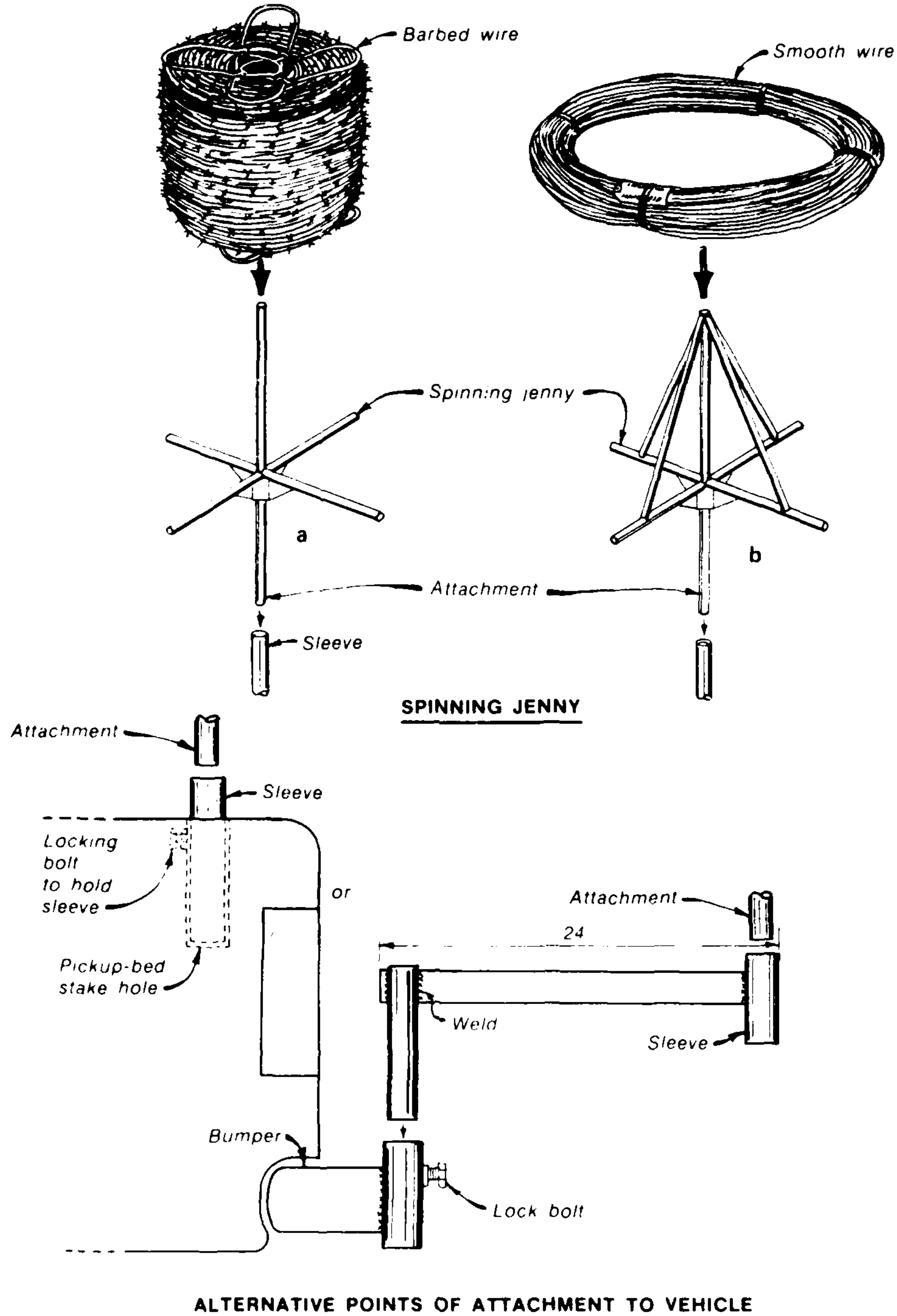


Figure 10. Wire dispensing tool (spinning jenny) designed to string barbed wire (a) and high-tensile wire (b). Wire can be dispensed by hand or by attachment of the spinning jenny to a vehicle

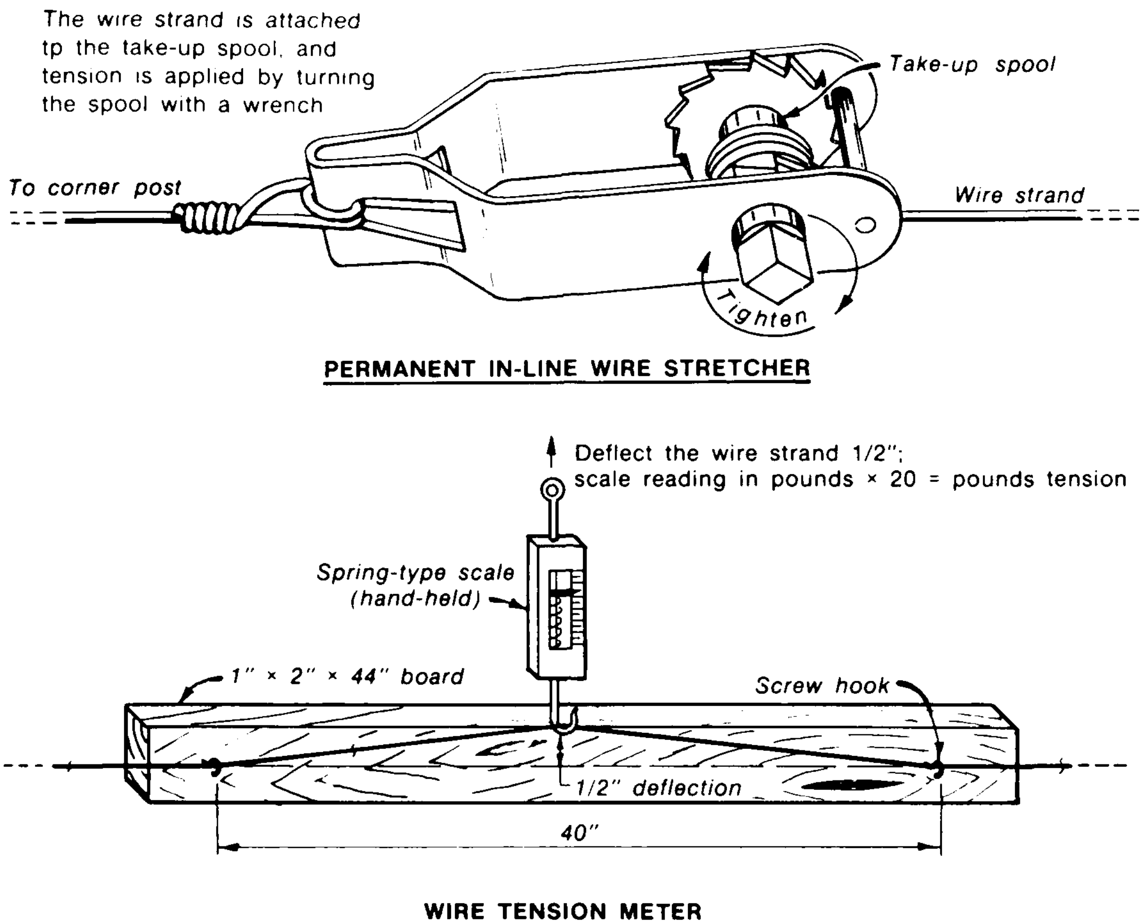


Figure 11. Permanent in-line wire stretcher (top) and a simple method of measuring wire tension with a meter comprised of a spring-type scale and board (bottom) (from Hanson 1982)

The top wire should be tied off so that it almost touches the top of the brace bars. The fit of the brace bar(s) to the corner and brace posts should then be checked; any slack or tendency of the posts to lean in the direction of pull can be removed with the guy-line and twist stick. The remaining wire strands should be attached following the same procedures used for the top strand. The strands should be stapled to all posts from top to bottom at the recommended heights. The top strand should also be stapled to all brace bars. Staples should always be driven downward at an angle to the grain of the wood.

Staples should not be driven tight against the strand, as a crimp or nick in the wire will weaken the strand and may cause wire breakage. Stays should be attached at equal distances between line posts.

Design Modifications

Fence lines crossing depressions and ridges will require special design modifications (Fig. 12). All posts installed in these situations should be at least 6 in. in diameter and set 4 ft deep. In moderate depressions, posts may need additional braces to keep them in place. Large rocks (≥50 lb) can be attached by guy-lines to prevent the post from pulling out. However, Hanson (1982) suggested using a "foot brace" to secure a post in the hole and keep it from lifting; the brace will also prevent a round post from twisting in the hole. A foot brace (Fig. 13) is made from 2- × 2- × 12-in. pressure-treated wood. One end of a 7-ft-long piece of 12-1/2-ga smooth wire is wrapped twice around the center of the foot, and the wire is tied off with 6 twists. The wraps are then stapled on the bottom of the foot to prevent them from slipping. Approximately 6 ft of wire should be left over to anchor the foot to the post. The corner post is placed in an enlarged hole (12-in.-diam) and positioned as described for a conventional corner post. The foot braces (2 per post) should be forced down each side of the post into the bottom of the hole. After the foot braces are in position, the anchor wires should be pulled up the side of the post and the hole filled. A chain-type wire stretcher should be attached to the post, and all slack should be pulled out of the anchor wires. The anchor wires should be wrapped around the post to counteract the tension that will cause a post to twist. Anchor wires should be stapled to the post.

Deep depressions require a separate section of fence, complete with corner posts, braces, and line posts. Depression and ridge fence wires should be strung and stretched with just enough tension to allow the wires to be positioned at the correct heights. Wire strands should be double-stapled to the posts with 2-in.-long staples, or special metal clips may be attached with 6d nails. In severe cases where staples keep pulling out, 1/2-in.-diam galvanized bolts and washers can be used (Fig. 14).

Construction of passable wildlife fences across drainage channels should not restrict waterflow. If the channel is narrow, with an intermittent flow, some type of swinging gate is usually best (USDA Forest Service 1972). A gate

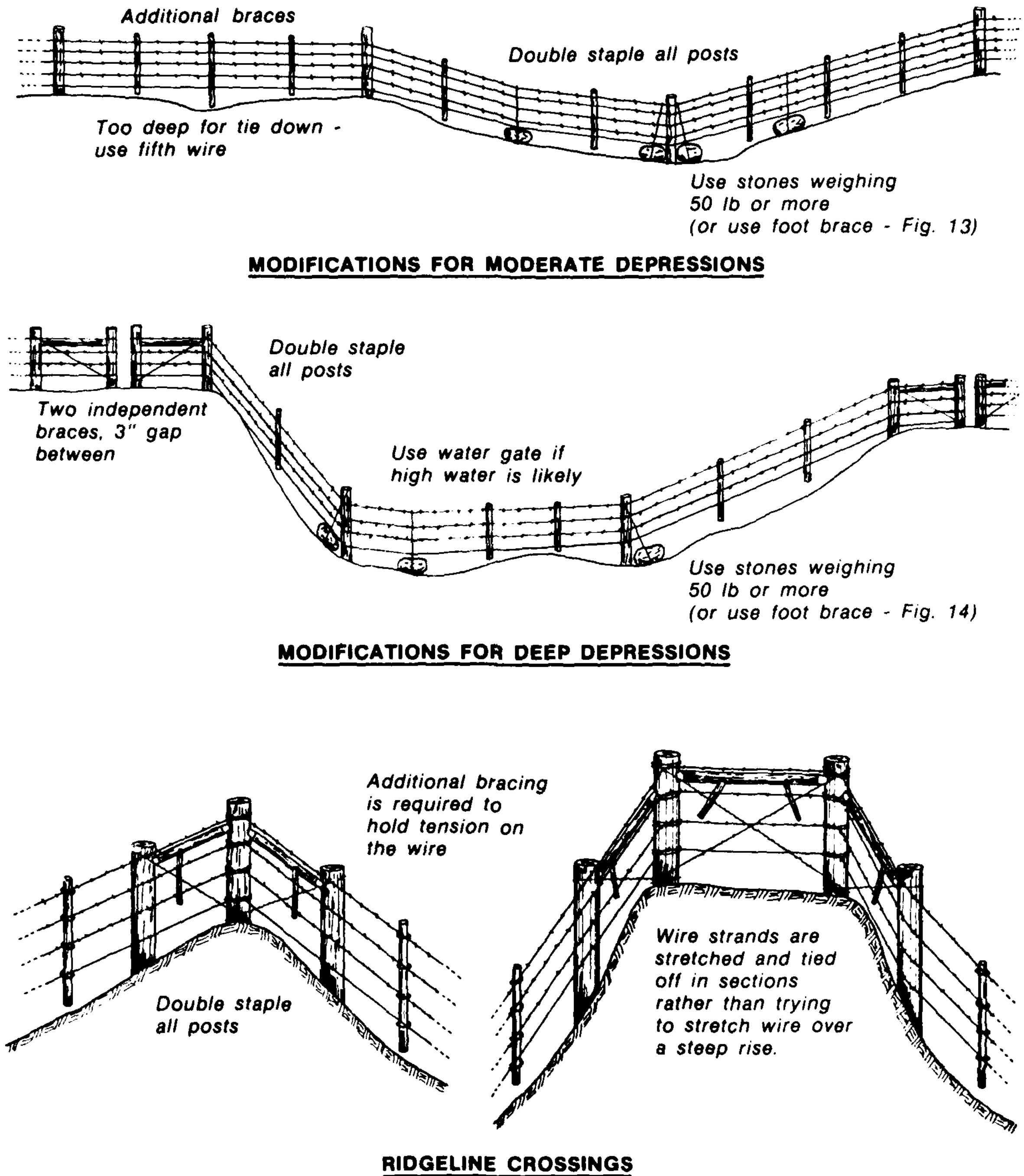


Figure 12. Design modifications for fences installed across depressions and ridgelines (after USDA Forest Service 1972)

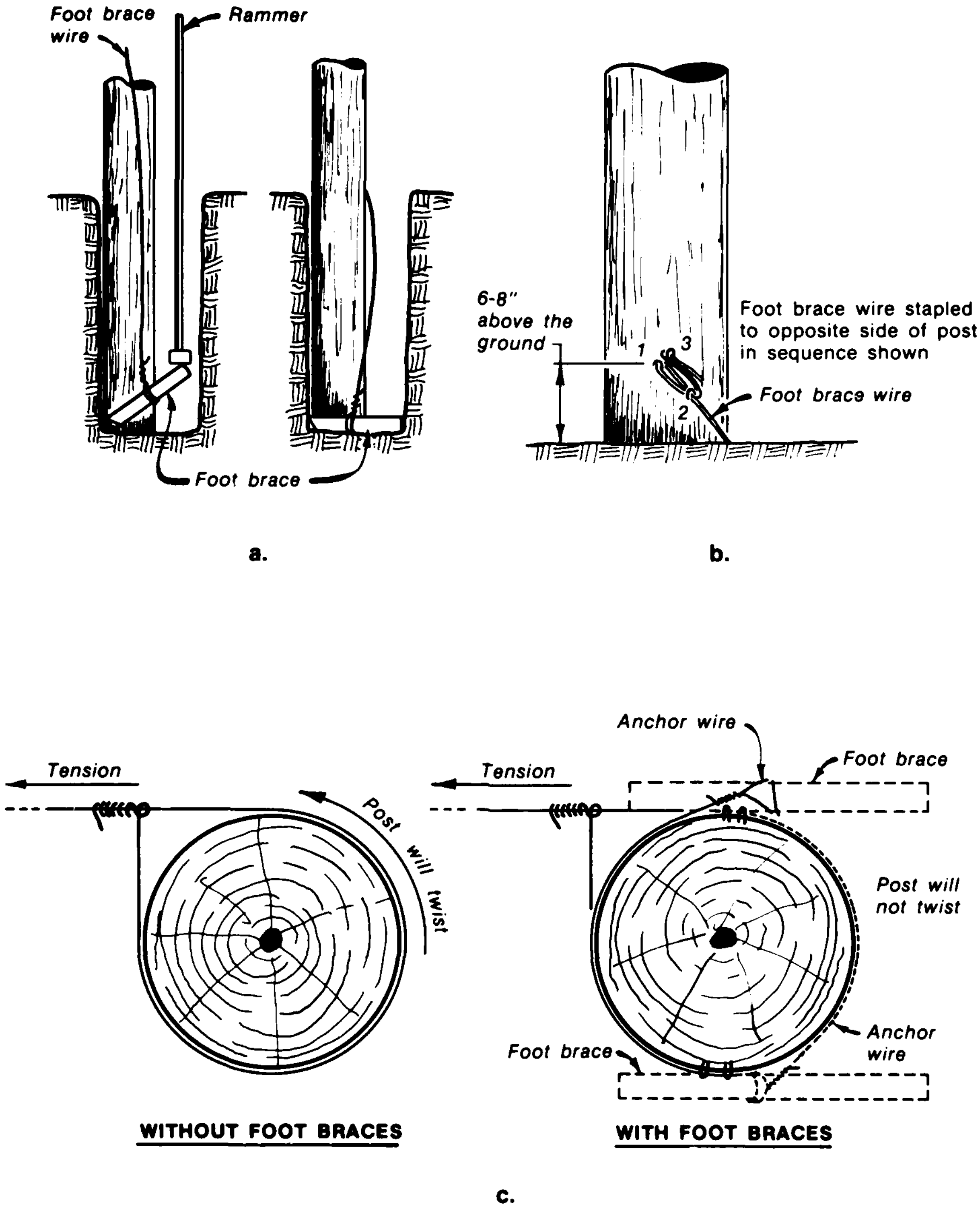


Figure 13. Foot brace installation showing: (a) method to prevent posts from lifting or twisting, (b) correct method of stapling the foot wire to the post, and (c) comparison of posts set without and with foot braces (from Hanson 1982)

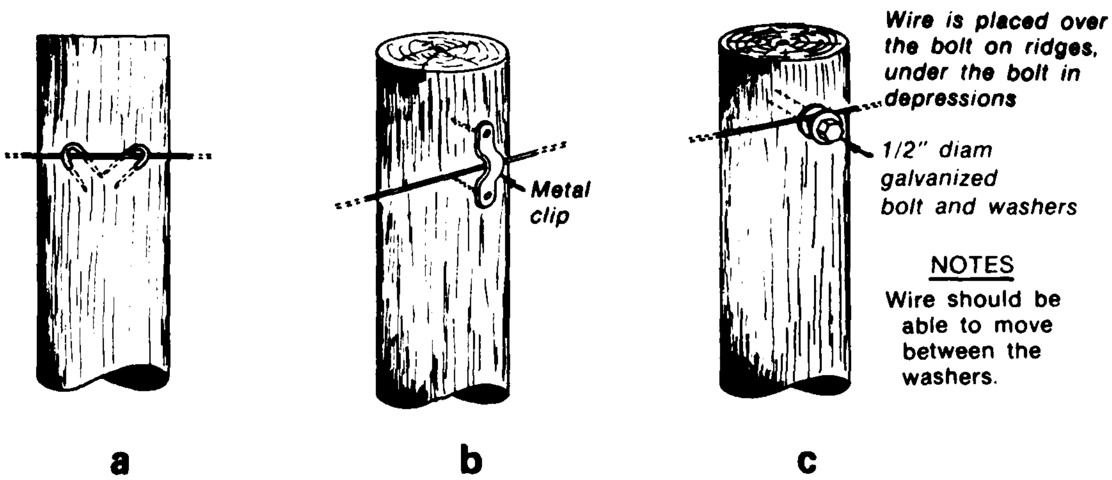


Figure 14. Methods of attaching wire to ridge and depression posts: (a) double staple, (b) metal clip, and (c) 1/2-in.-diam galvanized bolt and washers (tension keeps the wire strand between the washers)

can be made by suspending two 6-in.-diam logs with 9-1/2-ga smooth wire from a 1/2-in.-diam twisted steel cable strung between corner posts (Fig. 15a). As water rises in the creek, the logs float the gate out of the way. Where there is a large channel with a permanently flowing stream to be spanned, a slat-type of fence suspended from a 1/2-in.-diam cable can be effective (Fig. 15b). All types of water gap structures should permit wildlife to pass under them.

PLACEMENT

Any fence has the potential of becoming a problem to wildlife if it restricts access to food and water or causes physical injury through entanglement (Yoakum et al. 1980). The surest way to minimize the effects of fences on wildlife is to limit the number of fences, keep pastures or ranges as large as possible, and construct fences in such a way that wildlife can cross them at almost any point (Mapston 1972). Fenced areas should be able to meet wildlife requirements in years of drought and severe winters and allow for movement of all age groups in order to maintain healthy populations (Yoakum et al. 1980).

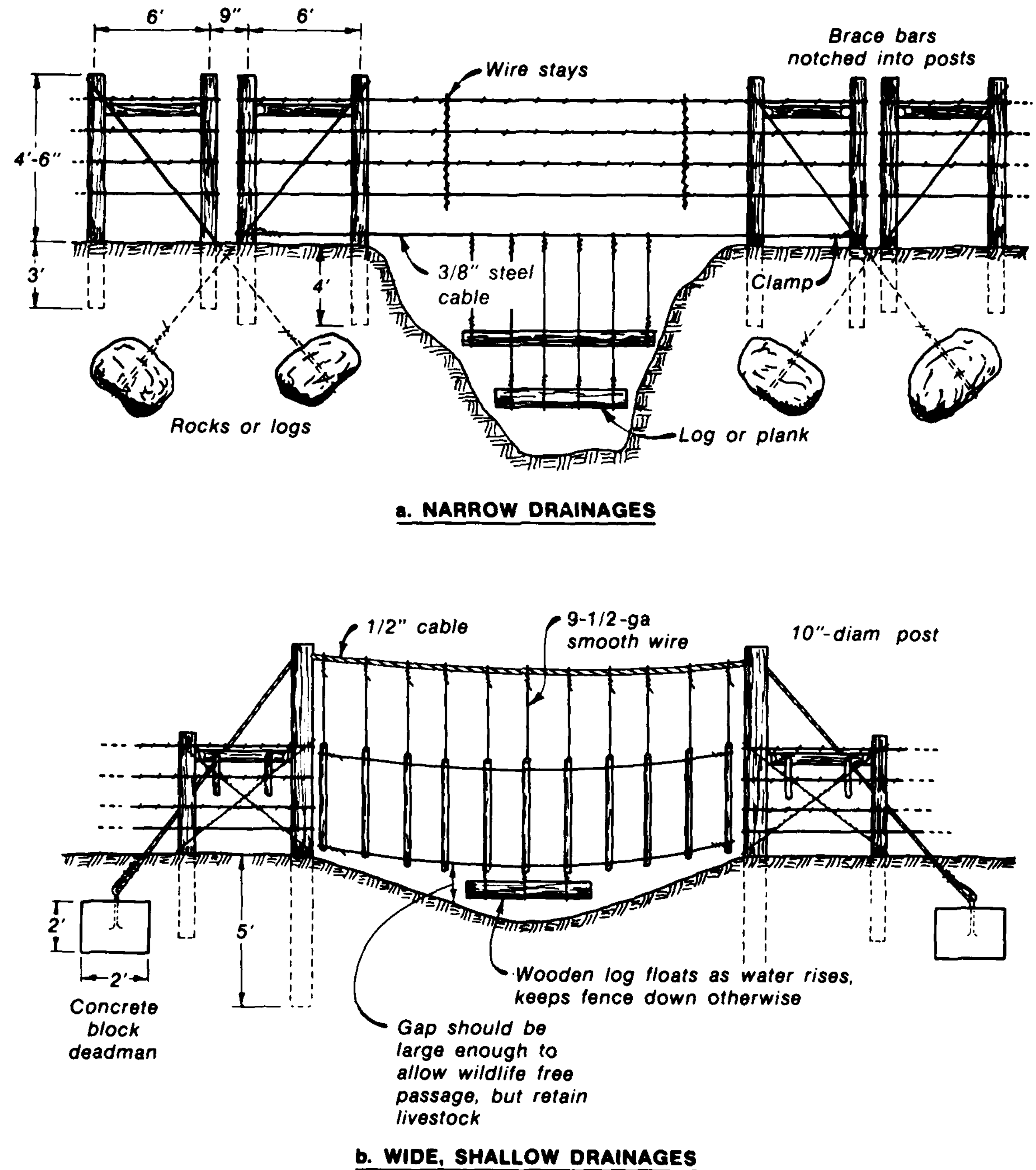


Figure 15. Special designs for passable fences constructed across drainageways (from USDA Forest Service 1972)

When possible, all fences should parallel migration routes of big game animals (Jerry W. Davis, USDA Forest Service, pers. commun., 1984). Fences that must cross migration routes should contain "lay down" fence panels that can be lowered during critical movement periods (see Section 5.2.2). Where watering ponds must be fenced, a pole or rail fence that will permit wildlife access but restrict livestock is recommended.

The complete fencing plan including gates, corrals, and water gaps should be plotted on a map and carefully correlated with projected management and improvement plans (Vallentine 1971). Determining the location and type of fence used involves a great deal of ground reconnaissance and consideration of the following factors:

(1) Project requirements.

(2) District and Project Office guidelines and regulations pertaining to fencing.

(3) Kind and class of livestock, if grazing leases are part of the management plan. A knowledge of forage preferences of livestock and wildlife helps make wise use of rangelands and aids in locating pasture and range boundaries for fence locations (Stoddart et al. 1943).

(4) Topography: Natural barriers (rocky ridges, ledges, gullies, and water) can be used effectively without conflicting with wildlife needs. Steep slopes and rocky terrain result in construction problems and increased costs and should usually not be fenced.

(5) Development and distribution of water: All fenced sites should contain adequate water to meet the needs of livestock and wildlife in drought conditions. Where livestock grazing is permitted, watering ponds should be fenced to prevent overuse and erosion of the land surrounding the pond and pollution of the water. Water troughs and guzzlers should be installed outside the fence for use by both livestock and wildlife.

(6) Season of use: Fences should be located so as not to restrict wildlife migration to summer and wintering areas and calving or fawning sites.

In addition, Hanson (1982) suggested that fence placement should:

(1) Separate seeded areas from native range.

(2) Exclude livestock and wildlife from hazardous areas (ponds, dams, spillways, and concrete-lined canals).

(3) Allow access for maintenance.

(4) Prevent interference with fire breaks, trails, and roads.

(5) Prevent livestock trailing through erosive areas.

MAINTENANCE

Fences should be maintained at, or as near as possible to, the standard to which they were constructed (USDA Forest Service 1972). A regular schedule of inspection and maintenance is necessary, and broken wires, posts, and staples must be replaced; routine work should also include maintaining access roads and fence lines. After construction a new fence will settle, the posts will tend to give, and wires will become slack. Therefore, the soil around posts should be retamped and the wires restretched as necessary to remove any sag. Maintenance ratings for the various fence designs are provided in Table 5.

Weather-related fence damage is very common. Heavy rains tend to cause soil erosion and washouts under fences, particularly at livestock trails, gullies, and creeks (Wade 1982). Damage also occurs from falling timber, windblown sand, heavy snowpack, and high vegetation. Fences should always be inspected for damage following severe storms; in snow country they should be inspected in the spring following snowmelt.

PERSONNEL AND COSTS

Material costs and man-hour requirements for construction and maintenance of fences vary relative to geographic location, topography, purchase quantities, and type of labor used (Jones and Longhurst 1958, Thompson 1979). Labor requirements for constructing 1 mile of wire fence on level terrain were reported by Waldrip (1962) as 112 man-hours when metal line posts were used; 168 man-hours were required when using wooden line posts. However, cost savings can be realized by manipulating the primary cost source--the fence itself (Jepson et al., undated). Fence construction and maintenance costs can be significantly reduced by modifying the number of posts and wire strands used. Additional cost savings can be made by implementing other proven fence designs, methods, and materials. A comparison of construction and labor costs for several fence designs is given in Table 5. For more information on these designs, refer to sections 5.2.2, Special Wire Fences, and 5.2.3, Impassable Fences.

CAUTIONS AND LIMITATIONS

Numerous livestock and some human losses have occurred by massive electrical currents traveling down fence wires as a result of lightning and/or

Table 5. Comparison of cost and maintenance for fence designs

Fence Design	Materials $/mile	Labor $/mile	Total $/mile	Maintenance Rating*
Conventional**				
3-wire barbed	2126	2100+	4226	III
4-wire barbed	2210	2100	4310	III
Special				
Suspension, wood stays	1268	634	1902	II
Suspension, wire stays	932	468	1400	II
Let-down, 4 wire	3612	2406	6018	V
High-tensile, 4 wire	1110	700	1810	II
Impassable++				
Upright	6184	3184	9368#	V
Slanting	5071	2100	7171	III

* Maintenance rating: I = lowest, V = highest. Maintenance rating was done on a ranking basis because actual dollar amounts are unavailable.

** From Jepson et al. (undated); values converted to 1982 retail.

+ Davis (1983, pers. commun.) reported that labor costs for fencing rough terrain could reach $5900/mile.

++ From Messner et al. (1973), values converted to 1982 retail.

Fencing costs per mile on steep, rough, or brushy range can run 50% or more than on level, brush-free range (Vallentine 1971). Moen (1983) estimated the cost of an upright impassable fence at between $11,880 and $20,000/mile.

powerline breakages (USDA Forest Service 1972). All wire fences should be grounded at each line brace, on each side of gates, and on each side of all powerlines that cross a fence. Fences can be grounded by connecting each wire strand together with 9-1/2-ga (minimum) copper wire or other good conductor. The copper wire should be connected to a metal grounding rod (3/4-in. galvanized steel pipe or 1/2-in.-diam steel rod) driven 3 ft into the ground. Grounding rods should be located not more than 300 ft apart (150 ft apart in dry, rocky soil). Proper grounding is also necessary to prevent deterioration of the fence wire by lightning, which causes rusting and loss of temper, thereby reducing longevity (Vallentine 1971).

Protective clothing, eye glasses, and leather gloves are recommended when building or maintaining fences, and extreme care should be employed when handling pressure-treated lumber. EPA labels and consumer information sheets must be strictly followed when applying wood preservatives. Barbed wire can injure the unprotected hands and face if handled carelessly, and the round shoulders of staples cause them to ricochet if not struck properly with a hammer. Wire stretching, if not done properly, is the most hazardous operation in fence construction. <u>Never</u> stretch wire with a vehicle because the breaking strength of wire can be quickly exceeded, resulting in a wire whip on personnel near the break. Follow manufacturer's recommendations for proper wire tension, and stretch wire only with the proper equipment.

The following recommendations and cautions should be considered when planning, constructing, or maintaining fences:

(1) Avoid high-drainage or high-runoff streambeds which necessitate costly water gaps (USDA Forest Service 1972).

(2) Tight fence construction with multiple strands of wire set around watering ponds provides very poor and dangerous access for wildlife.

(3) The unappealing visual effect of straight-line swaths running up mountain sides can be avoided by not cutting the trees and shrubs that are adjacent to but not directly on the fence line (Maser et al. 1979).

(4) Livestock may trail along fence lines that are set perpendicular to a slope, thus causing water-related erosion problems (USDA Forest Service 1972).

(5) Fence angles of 45 deg or less create pockets that may trap or otherwise hinder animal movement.

(6) Sharply angling or curving fences are difficult and costly to brace.

(7) Remove unnecessary fences and loose wire that might trap or snare livestock and wildlife. Old fence posts should be left in the

ground in areas lacking suitable vegetation for raptor perches (Maser et al. 1979). Old posts are also suitable as base logs in brushpile construction.

(8) Removal of the herbaceous ground cover must be avoided when installing fences on steep grades and erosive soils (Vallentine 1971). In heavily timbered or very rough and rocky terrain, clearing must generally be reduced to a minimum. Where herbaceous cover has been removed, reseeding with grasses should follow. Revegetation of fence lines cleared of vegetation in desert areas is particularly difficult because such areas are susceptible to infestations of noxious plants.

LITERATURE CITED

Antelope States Workshop. 1974. Fencing on pronghorn antelope range. Proc. Antelope States Workshop 6:181-183.

Hanson, M. L. 1982. Pocket handbook for hi-tensile fencing. Agri-Fence Publ., Rough and Ready, Calif. 56 pp.

Henderson, G. E. 1966. Planning farm fences. Am. Assoc. for Agric. Eng. and Vocational Agric., Athens, Ga. 54 pp.

Interstate Antelope Conference. 1962. Recommended specifications for barbed wire fences (for benefit of livestock and wildlife). Trans. Interstate Antelope Conf. 13:100-101.

Jepson, R., R. G. Taylor, and D. W. McKenzie. Undated. Rangeland fencing systems: State-of-the-art review. Unpubl. manuscript. 30 pp.

Jones, M. B., and W. M. Longhurst. 1958. Overhanging deer fences. J. Wildl. Manage. 22:325-326.

Leighton, J. 1978. Guide to fencing. Supplement to the New Zealand Farmer, April 17. 48 pp.

Mapston, R. D. 1972. Guidelines for fencing on antelope ranges. Proc. Biennial Antelope States Workshop 5:167-170.

Maser, C., J. W. Thomas, I. D. Luman, and R. Anderson. 1979. Wildlife habitats in managed rangelands--The Great Basin of southeastern Oregon; Manmade habitats. USDA For. Serv. Gen. Tech. Rep. PNW-86. 40 pp.

Messner, H. E., D. R. Dietz, and E. C. Garrett. 1973. A modification of the slanting deer fence. J. Range Manage. 26:233-235.

Moen, A. N. 1983. Agriculture and Wildlife Management. Corner Brook Press, Lansing, New York. 367 pp.

Stoddart, L. A., A. D. Smith, and T. W. Box. 1943. Range Management. McGraw-Hill Book Co., New York. 532 pp.

Thompson, B. C. 1979. Evaluation of wire fences for coyote control. J. Range Manage. 32:457-461.

USDA Forest Service. 1972. Structural range improvement handbook. USDA For. Serv., FSH 2209.22, R-3. 316 pp.

U.S. Fish and Wildlife Service. 1978. Western reservoir and stream habitat improvement handbook. U.S. Fish and Wildl. Serv., Biol. Serv. Program, FWS/OBS-78/56. 250 pp.

Vallentine, J. F. 1971. Range Developments and Improvements. Brigham Young Univ. Press, Provo, Utah. 516 pp.

Wade, D. A. 1982. The use of fences for predator damage control. Proc. 10th Vertebrate Pest Conf. 10:24-33.

Waldrip, W. J. 1962. Fence costs: six kinds compared. Am. Cattle Producer 44:8.

Warmbrod, J. G., and J. T. Beavers. 1963. A simple method of treating fence posts. Univ. Tenn. Agric. Ext. Serv. Publ. 465. 8 pp.

Yoakum, J., W. P. Dasmann, H. R. Sanderson, C. M. Nixon, and H. S. Crawford. 1980. Habitat improvement techniques. Pages 329-403. In S. D. Schemmitz, ed. Wildlife Management Techniques Manual. The Wildl. Soc., Washington, D.C. 686 pp.

END
10-86
DTIC